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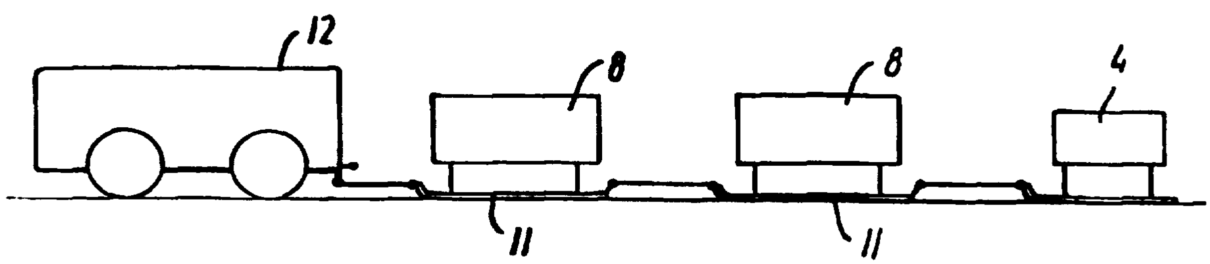

(57) Abstract

A method and a measurement equipment (1) serving for mapping the geology in a subterranean formation, upon which there are placed at least one receiving coil (4) and at least one transmitter coil (3). A transient electromagnetic probing is used, where an electric current is brought to flow through the transmitter coil and transmit a magnetic moment for building up a magnetic field in the formation, whereafter the electric current suddenly is interrupted, and the consecutive decay of the builded magnetic field is measured in form of decay signals by means of the receiving coil. The measurement equipment comprises a number of transmitter coils, which are adapted in a chronological order to transmit a combination of magnetic moments. Thereby the geology of the subterranean formation can be mapped quickly and precisely in such close measurements, that a valuation of the quality of the individual probing can be evaluated by correlation.

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A method and measurement equipment for mapping the geology in a subterranean formation.

The invention concerns a method for mapping the geology in a subterranean formation, and which comprises that above the formation there is placed at least one receiving coil and at least one transmitter coil, that there by letting an electric current flow through at least the one transmitter coil a magnetic moment is transmitted for building up a magnetic field into the formation, that the electric current suddenly is interrupted, and that the consecutive decay of the magnetic field built up is measured in form of decay signals by means of the at least one receiving coil.

Such a method, which among persons skilled in the art, is called a transient electromagnetic probing, has been known for years and is extensively used within mineral prospecting. In recent years the method has gained a growing use within the mapping of the ground water resources.

For mapping the ground water resources transportable equipment is used. The equipment consists of a transmitter unit with a corresponding transmitter cable and a receiving unit with a corresponding receiving coil. The transmitter cable is upon the surface of the ground laid out in a circuit, the transmitter coil, typical a square of 40 x 40 metres, and is connected to the transmitter unit. The receiving coil is placed in the middle of the transmitter circuit (Eng. central loop) or outside the transmitter circuit (Eng. offset loop). Some equipment uses the transmitter coil as a receiving coil as well (Eng. coincident loop).

From the transmitter unit the transmitter coil is supplied with electric current of a size of typically 1 - 5 amperes. The current is after a short time, typically 5 - 10 milliseconds, suddenly interrupted, and the magnetic field, which the electric current in the transmitter coil has built up, is thereafter monotonously decaying with increasing decay time and is inducting a voltage, the decay signal, in the receiving

coil. By means of the receiving unit the decay signal is measured. The decay signal will quickly become smaller than the size of the noise signal, present at all time, the "noise floor". It is therefore necessary to use a synchrony detection technique in order

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inter-pretation of the individual probings it is possible to have an evaluate of the electrical resistance structure of the formation and thereby of the geological structure along the profile lines. The result of the interpretation from the individual line profiles can through inter-polation be put together to a map covering the area of the electrical resistance conditions and the structure of the geology in an area.

The transient electromagnetic method is used with great success within the mineral prospecting, since many mineralizations are heavily electric conductive in relation to the mother rocks into which they are deposited. Since large areas are to be investigated, instruments have been developed for being used from aeroplanes. Hereby it is possible to measure in close profile lines, and the results can be put together to a map covering large areas. Due to the fact that large transmitter current strength have to be used and also the flying height, the decay signal cannot be measured to early decay times. This fact is, however, of no importance for this type of prospecting.

Through the last years the transient electromagnetic prospecting has become very popular in the mapping of the ground water resources. In order to be able to make this mapping satisfactory, it is necessary to use instruments which can measure the decay signal in decay times from a few microseconds to 5 - 10 milliseconds.

Contrary to the instruments, which are used by aircraft measurement, the decay signal can by instruments for use upon the surface of the ground be measured in the time interval from a few microseconds, after the transmitter current has been interrupted, to 5 - 10 milliseconds. By aircraft measurement will, as mentioned, be used instruments with large transmitter current strength, which means that the current in the transmitter coil slowly will decrease after the interruption of the current supply, in form of a so-called blanking current. Thereby the measurement of the decay signal to early decay times will be influenced by the blanking current in the transmitter coil and be inapplicable for being used for a interpretation. Also the size of the decay to early decay times is very much dependant of the distance to the surface of the ground and the topography of this. It is very difficult to adjust adequately for these influences. By mineral prospecting these influences are without importance since the decay signal to late decay times gives the wanted identifications of the presence of the deductive mineralizations. The instruments can, however, not be used by mapping of the ground water resources, since in this case it is necessary to acquire knowledge of the decay signal in the early decay times.

Transient electromagnetic probing for mapping of the ground water resources will therefore have to be performed with transportable equipment for application upon the ground of the earth.

By transient electromagnetic probings there are several different sources of error which must be taken into account. One of these is the influence from the magnetic noise field, which induces a magnetic noise signal in the receiving coil. This field has a natural origin from frequent thunderstorms around the equator and from the interaction of the sun wind with the stationary geomagnetic field. But in cultural built-up areas there are furthermore large magnetic noise areas, which derive

from electric cables and electric machines, and which furthermore induce a cultural noise signal in the receiving coil. These noise signals will frequently disturb the measurement of the decay signal and distort it, whereby a interpretation of the signal becomes uncertain. Finally, the decay of the magnetic field, which comes from the interruption of the current in the transmitter coil, will couple to electric conductive objects in the surroundings, such as underground cables, electric high-voltages cables, electric conductive metal fences etc. and create a coupling noise signal. This coupling noise signal is a deterministic noise signal in phase with the transmitted, contrary to the magnetic noise signal and the cultural noise signal, which to a high extent can be regarded as stochastic, casual signals.

It is therefore not possible through synchrony detection, a averaging in average windows or other statistic treatment to remove the influence from this coupling noise signal.

The coupling noise signal will therefore, in dependence of its strength, make a interpretation of the measured decay signal uncertain or directly wrong. In order to avoid the influence from the coupling noise signals, the transient electromagnetic probings are made at adequate distance, typically 100 - 200 metres, from electric conductive subjects. But in practice it is impossible to know all the coupling possibilities, and it is a great and extensive work to get information's about cable connections, tubing arrangements, fences, etc.

The optimum would therefore be to measure with the smallest possible distance between the probings. Probings, which are very close, will be correlated to the same extent as the underlying electric conductive geological structure will be. By assuming a given correlation in the geological structure, there can be made a correlation between the probings, whereby the quality of the individual probings can be evaluated.

The known measurement technique makes it rather seldom possible to be able to make measurements with a closeness, which satisfy the requests a geological correlation between the individual probings requires, since the field work will become very extensive and the costs too high. The probings will therefore be carried out at mutual distances, which make the use of correlation for valuation of the data quality of the measurement difficult or directly useless. The data quality of each individual probing will then have to be evaluated by itself. In an area with a highly variating geology, as e.g. in glacial landscapes such as in Denmark, with large cultural noise signals and numerous possibilities of the presence of not known coupling signals, this is often an utmost difficult work.

It will therefore be the knowledge and experience of the interpretation geophysicist which will be the basis for the valuation of the quality and ability to be interpreted of the individual probing.. A situation which is unsatisfactory, since the coupling noise signals often resemble true decay signals to confusion and therefore not can be isolated.

By mapping of ground water resources large areas are often to be covered in order to obtain the regional understanding and insight in the connections and structures of the magazines. This means, that a great number of probings have to be made by such investigations in order to be able to build up a map over the geological structures. This work is comprehensive and will in some cases not be carried out due to the involved financial costs. This in spite of the fact, that the experiences fully have shown, that the transient electromagnetic method can give a detailed picture of the geological structure of the subsoil. A picture, which a.o. in Denmark is necessary in order to be able to make an optimum planning of the exploitation of the by degrees short water resources

The object of the invention is to provide a method of the type mentioned in the opening paragraph, by which the geology in an subterranean formation more easily, more quickly and more precisely than known up till now can be mapped by means of a transient electromagnetic probing, and with which so close measurements easily can be carried out, that a valuation of the quality of the individual probing can be evaluated by means of correlation.

The new and unique whereby this is obtained is according to the invention that there in a chronological order is transmitted a combination of magnetic moments, whereby specifically magnetic fields can be created, which fields are adjusted to the various depths in the formation. Thereby it is possible to measure decay times from a few microseconds to 5 - 10 milliseconds and carry out a precise mapping of the formation in the various depths.

It is an advantage when at least two of the magnetic moment transmissions of the combination are of different size, and that the combination comprises at least one magnetic moment transmission for measurement of the timewise early parts of the decay signal, at least one magnetic moment transmission for the measurement of the timewise late parts of the decay signal, and at least one magnetic moment transmission for the measurement of the timewise parts of the decay signal which are between the early and the late parts. Thereby the measurement process can be optimised.

The invention also concerns a measurement equipment for mapping the geology in an subterranean formation, and which comprises at least one transmitter coil for placing above the formation and for building up a magnetic field in said coil by means of the magnetic moment, which the coils transmits, when an electric current is flowing through, and at least one

receiving coil for placing above the formation and in form of decay signals measuring the decay of the magnetic field builded up, after the current through the transmitter coil suddenly has been interrupted. The new and unique according to the invention is that this measure equipment comprises a number of transmitter coils, which in a chronological order are adapted to transmit a combination of magnetic moments.

Further expedient qualities of the measurement equipment according to the invention are stipulated in the independent claims.

The invention will be explained more fully below by the following description of embodiments, which just serve as examples, with reference to the drawing where,

Fig. 1 schematically shows a measurement equipment with a transmitter coil and a receiving coil shown in two different positions during the mapping of the geology in a subterranean formation,

Fig. 2 is a diagram which shows the decay signal as a function of time,

Fig. 3 are diagrams, which show the measurement of the decay time in time intervals or averagewindows stipulated in a linear and a logarithmic scale, respectively,

Fig. 4 is a diagram, which shows a measurement equipment corresponding to the electronic blanking circuit with voltage limiting loss resistances shown in fig. 1,

Fig. 5a shows schematically, seen from the side, the transmitter and the receiving coils of the measurement equipment placed on sledges in a row which are pulled by a traction vehicle,

Fig. 5b shows the same, seen from above, but with folded transmitter coils, and

Fig. 6 shows schematically the receiving coil, which via an amplification circuit is coupled to a computer unit.

In fig. 1 can be seen a typical measurement equipment, which generally is designated by the reference number 1. The measurement equipment is placed above a geological formation 2, which is to be mapped. A transmitter coil 3 and a receiving coil 4 are connected to a receiver/transmitter 5. The receiving coil 4 is placed inside the transmitter coil 3, but can alternatively be placed outside as the receiving coil 4, which in the figure is shown with a dotted line. When electric current is sent through the transmitter coil, the currents 6 are induced in the formation. Thereby a magnetic field is built up in the formation.

When the current suddenly is interrupted, the magnetic field is decaying, whereby a voltage is induced, the decay signal in the receiving coil. This decay signal is used for the interpretation of the geological structure of the formation.

Fig. 2 shows, in form of a diagram, how the decay signal is decreasing step by step and quickly becomes smaller than the present noise signals, "the noise floor". When the decay signal becomes smaller than the noise floor, it is isolated from the noise signals by means of a synchrony detection technique, and also by supplying the receiver with so-called average windows. Thereby is meant, that the measurement of the decay signal takes place in successive time intervals, in which the signal is averaged. The windows are getting wider and wider at increasing time of decay, as shown in fig. 3, where the with is stipulated as a function of the time in a linear scale at the top and a logarithmic scale at the bottom. In the last

mentioned scale the average windows have the same with, or they have, said in another way, the same length of interval.

The transmitter coils of the known equipment for application upon the surface of the ground will typically have the dimensions of 40 x 40 metres or more in order to be able to carry out measurements of the decay signal to decay times from a few microseconds to 5 - 10 milliseconds. By coils of this size it is possible to transmit such a heavy magnetic field, that the decay signal can be measured in said time interval and at the same time be certain of the fact that the decay signal will not be influenced by the blanking current to the early decay times.

The size of the transmitted magnetic field depends of the transmitted magnetic moment of the transmitter coil, which broadly can be expressed by (the current in the coil before it is switched off) x (number of windings of the coil) x (the area of the coil). From this can be seen, that a coil with a small extension requires many windings and/or large current intensity if it shall be able to transmit the same magnetic moment as a coil with a large extension.

A coil with many windings has a large self-induction, since the self-induction broadly is depending upon, (the number of windings of the coil) x (the number of windings of the coil) x (the diameter of the coil). A small coil with many windings will then have a large self-induction as compared with a large coil with one or few windings. Since the blanking time of the current, defined as the time, where the blanking current can influence the measurement of the decay signal of en transmitter coil, depends of the size of the initial current and the self-induction, it will not be possible for the one and only transmitter coil to transmit such a magnetic moment, that the decay signal for early decay times can be measured undisturbed by the blanking current in the transmitter coil, and at the

same time be able to measure the decay signal below the noise floor to late decay times. With one little transmitter coil it will thus not be possible to measure the decay signal in the time interval from a few microseconds to 5 - 10 milliseconds.

By means of the method and the measurement equipment according to the invention it is, however, as it appears from the following explanation, now possible to measure the decay signal in the time interval from a few microseconds to 5 - 10 milliseconds by using small transmitter coils, which typically can be e.g. 2 x 2 metres.

In order to obtain that the blanking current dies away from the transmitter coil as fast as possible, is used, as shown in fig. 4, an electronic blanking current circuit 7, which is able to interrupt the current supply to the transmitter coil 8 almost momentarily. The circuit contains at the same time a voltage limiter 9, typically 400 - 800 volt, since the voltage above the transmitter coil otherwise would raise to very largest sizes, typically many kilovolt, and thereby destroy the electronic blanking current circuit.

Furthermore, there can between the separate windings on the coil be inserted loss resistances 10 in order to make the blanking current die out faster.

Finally, the coil can be winded in such a way that it reduces the winding capacity as much as possible, since the winding capacity together with the self-induction in the coil make an oscillation circuit, which in the blanking process can self-oscillate and thereby prevent a fast dying out of the blanking current. These described techniques are know from various parts of the electronic science.

In order to make the blanking current die out faster in the transmitter coil, more of the electronic blanking current

circuits, as shown in fig. 4, can be inserted, such that there simultaneously can be disconnected over winding sections in the transmitter coil. This will furthermore reduce the dying out time for the current.

By means of the above mentioned techniques it is possible, with a row of small transmitter coils and receiving coils in combination, continuously to make transient electromagnetic probings, while the coils are dragged across the surface of the ground and are measuring decay signals to decay times from a few microseconds to 5 - 10 milliseconds.

In order to make it possible for the transmitter coils and the receiving coils to be dragged across the surface of the ground in a quick and efficient way it is necessary that these have small dimensions, typically 2 x 2 metres. Furthermore, it must be possible to fold the coils quickly or somehow make the coils lengthy when passing living fences or similar obstacles in the landscape.

The transmitter coils typically have dimensions which do not make an obstacle when being dragged through the landscape. Typically, they will therefore have the shape of a tube with diameters of less than 10 cm, bended double into a circle with a diameter of 1 metre or less.

With great advantage there can be used several transmitter coils with separate electronic blanking current circuits. As shown in fig. 5a, b, c, these transmitter coils 8 are then placed together with receiving coils 5 in a row upon sledges 11, so that the transmitter coil, when transmitting (fig. 5a, b), quickly and easily can be dragged across the surface of the ground by a traction vehicle 12, and be folded together (figure 5c) such that the row will take up as less room as possible in the width when it has to pass fences or similar obstacles in the landscape. Due to the fact, that these

transmitter coils when being placed next to each other have a minimal coupling, the dying out of the blanking current in the individual transmitter coils will be independent of each other. The assembled transmitted moment will be the total of the moments from the individual transmitter coils.

The sledges, which carry the transmitter and the receiving coils, can advantageously be longitudinal, so that they will obtain a steady movement when dragged a terrain.

By means of the above mentioned method it will be possible to obtain a larger transmitted magnetic moment at the blanking times, which apply for the individual incoming transmitter coils in the row.

In order to be able to measure the decay signal in total of the wanted time interval, systems are used consisting of transmitter coils with electronic blanking current circuits of the said type. The decay signal is measured in time segments for which is used an adequate combination of transmitter coils and blanking current circuits, a transmitting system, where the blanking time is adequately short in order to not disturb the measurement of the decay signal, and where the transmitted magnetic transmitter moment is adequately powerful to be able to carry through a measurement.

By using several transmitting systems in a, by these systems constructed so-called segmented, transmitter with adequate blanking times and magnetic transmitting moments, the assembled decay signal can be made up in the decay time interval, as wanted. The transmitting system with a small magnetic transmitter moment will typically have short blanking times and will therefore could be used for measurement of decay signals to early decay times and transmitting systems with large transmitter moments will normally have long blanking times and

will therefore could be used for measurement of the decay signal to late decay times.

When the inducing current in the formation from the decay in the magnetic field is reducing, it becomes more and more diffuse and includes an increasing area of earth volume. Therefore, the lateral resolution will decrease with growing depth of the induced currents. The decay signal to the early decay times are connected to the induced currents near to the surface and the decay signal to the late decay times are connected to the deep induced currents. Typically, the earth volume, which is connected to the induced currents, will have a diameter in a lateral direction of two to three times the depth of the induced currents.

A single measurement of a decay signal to late decay times (1 - 10 milliseconds) will typically take 20 milliseconds, and opposite to that, a measurement to early decay times (10 - 100 microseconds) will typically take 1 - 3 milliseconds. By the synchrony signal treatment of the decay signal there will typically be recorded 1000 individual measurements. An assembled recording of the decay signals to late decay times, coming from the currents in the large depths, will together typically last 20 seconds. At movement velocities of the coils of 2 - 3 km per hour the coils will in this period of time typically have moved 10 - 20 metres, which with the said lateral recordings will be of no importance.

The method for the measurement of the assembled decay signal is then to use a combination of magnetic moment transmissions, in which there between the large and time requiring magnetic moment transmissions are transmitted smaller, not so time-consuming, magnetic moments. There can typically be used three to five different magnetic moment transmissions with one moment for the late timewise parts of the decay signal, one for

the medium timewise parts, and one to three for the early parts of the decay signal.

The receiving coil is, as mentioned before, a smaller coil, typical 1 metre in diameter, and typically screened in such a way, that its capacitive coupling to the surface of the ground can be kept constant. To the receiving coil is, as shown in fig. 6, coupled a receiving circuit 13 with typically a cascade coupling of amplifiers 14 with smaller and smaller band with. After each amplifier the signal is taken out, which after an analogous to digital conversion with converters 15, AD-conversion, with sampling time of typically 1 to 2 microseconds, is transmitted to a computer unit, typically through a light cable in order to avoid over-coupling of digital noise from the computer unit.

By this is obtained a row of more and more amplified and band limited recordings of the decay signal, so-called signal segments.

The structure of the decay signal such is, that it for the early decay times have a high frequency content, typically 400 - 800 kHz, while it for the late decay times have a low frequency content, typically 1 - 5 kHz. Since the noise content in the measured signal is reduced by using a band limitation, it can be obtained that the noise for late decay times will be heavily reduced, due to the fact, that large band limitation is used here.

In the known instruments for measurement of transient electromagnetic probings this band limitation is made in such a way, that the decay signals in the individual decay signals segments will not be influenced by the band limitation. The reason for this is, that it is not possible to take this into account in the interpretation.

In the measurement equipment according to the invention a very strong band limitation is used in the individual signal segments as thereby a large noise reduction is obtained. By having such a large noise reduction, the magnetic transmitter moment can be reduced with maintenance of a satisfactory signal/noise relation. This has especially great importance by the recording of the decay signal for large decay times, because here there shall be used a large magnetic transmitter moment.

For the interpretation of these results a particular interpretation programme has been developed, which in its calculations of model curves includes this distortions of the decay signal coming from the heavy band limitation.

Thereby there can, under the given conditions, be obtained better results, but the programme does not necessarily have to be used, since there instead can be recorded more single shots and in this way be obtained analogously good results, but at the expense of the driving velocity.

The decay signal in the total desired decay time interval is, according to the invention, assembled of the individual decay signals coming from the individual segmented magnetic moment transmissions and from the measured signal segments.

Especially the cultural noise signal, but also the magnetic noise signal, is often present in spikes or bursts, and by a digital predicative filtering of the separate decay curves, in which these are mutually correlated in the same series, the measurements will, being especially strongly influenced by noise, be filtered away, whereby an improved evaluating of the decay signal from the series will be obtained.

This digital signal treatment also reduces the noise from the movement of the receiving coil, the drag noise. When the

sledge with the receiving coil is moved across the surface of the ground, sudden pushes or jerks can give especially violent movements of the receiving coil. Thereby there can be induced noise signals in the coil coming from the movement of the coil in the stationary magnetic earth field. This noise is equally present as spikes or bursts, and requires a digital signal treatment like the one described above in order to be able to be filtered away.

As mentioned before, the influence from the coupling noise is determinated by the correlation between close probings. Another technique, which the invention's application of small transmitter coils makes it possible to use, is the measurement of decay signals from vertical transmitter coils. The coupling to earth cables, high-voltage lines, metal fences or similar oblong conductors on or close to the surface of the ground is minimised by the use of such vertical transmitter coils. Thereby it is possible through correlation with decay signals from horizontal and vertical transmitter coils to map the coupling phenomena.

It is furthermore possible to map the geological structures with decay signals from vertical transmitter coils.

As a further possibility exists the use of the invention for mapping with helicopter, where transmitter coils and receiving coils can be moved across the surface of the ground.

Claims

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1. A method for mapping the geology in a subterranean formation, and which comprises:

- that there above the formation is placed at least one receiving coil and at least one transmitter coil,

- that there by letting an electric current flow through at least the one transmitter coil is transmitted a magnetic moment for building up a magnetic field into the formation,

- that the electric current suddenly is interrupted, and

- that the consecutive decay of the magnetic field builded up is measured in form of decay signals by means of the at least one receiving coil,

c h a r a c t e r i z e d in,

that there in a chronological order is transmitted a combination of magnetic moments.

2. A method according to claim 1, c h a r a c t e r i z e d in that at least two of the magnetic moment transmissions of the combination are of different size.

3. A method according to claim 1 or 2, c h a r a c t e r i z e d in that the combination comprises at least one magnetic moment transmission for the measurement of the timewise early parts of the decay signal and at least one magnetic moment transmission for the measurement of the timewise late parts of the decay signal.

4. A method according to claim 3, c h a r a c t e r i z e d in that the combination also comprises at least one magnetic moment transmission for the measurement of the timewise parts of the decay signal being between the early and the late parts.

5. A measurement equipment for mapping the geology in an subterranean formation, and which comprises:

- at least one transmitter coil for placing above the formation and for building up a magnetic field in said formation by means of the magnetic moment, which the coil transmits when an electric current flows through the coil, and

- at least one receiving coil for placing above the formation and in form of decay signals measuring the decay of builded magnetic field, after the current through the transmitter coil suddenly has been interrupted,

c h a r a c t e r i z e d in,

that the measurement equipment comprises a number of transmitter coils which are adapted, in a chronological order, to transmit a combination of magnetic moments.

6. A measurement equipment according to claim 5, c h a r a c t e r i z e d in that at least two of the transmitter coils have different blanking times.

7. A measurement equipment according to claim 5 or 6, c h a r a c t e r i z e d in that there in at least one of the transmitter coils are inserted more electronic blanking current circuits for simultaneously switching off the winding sections in the transmitter coil.

8. A measurement equipment according to claim 7, c h a r a c t e r i z e d in that each transmitter coil has a greatest geometric extension in operation position of between 1/4 and 15 metres, preferably between 1/2 and 10 metres and especially between 1 and 6 metres.

9. A Measurement equipment according to each of the claims 5 - 8, c h a r a c t e r i z e d in that each of the transmitter coils can be folded up to an oblong unit.

10. A measurement equipment according to each of the claims 5 - 9, c h a r a c t e r i z e d in that the transmitter and the receiving coils are coupled together in rows and placed upon transport means, such as sledges.

AMENDED CLAIMS

[received by the International Bureau on 16 September 1996 (16.09.96); original claims 1-10 replaced by amended claims 1-9 (3 pages)]

1. A method for mapping the geology in a subterranean formation, and which comprises:

- that there above the formation is placed at least one receiving coil and at least one transmitter coil,

- that there by letting an electric current flow through at least the one transmitter coil is transmitted a magnetic moment for building up a magnetic field into the formation,

- that the electric current suddenly is interrupted, and

- that the consecutive decay of the magnetic field builded up is measured in form of decay signals by means of the at least one receiving coil,

- that there in a chronological order is transmitted a combination of magnetic moments.

c h a r a c t e r i z e d in that at least two of the magnetic moment transmissions of the combination are of different size.

2. A method according to claim 1, c h a r a c t e r i z e d in that the combination comprises at least one magnetic moment transmission for the measurement of the timewise early parts of the decay signal and at least one magnetic moment transmission for the measurement of the timewise late parts of the decay sicnal.

3. A method according to claim 2, c h a r a c t e r i z e d in that the combination also comprises at least one magnetic moment transmission for the measurement of the timewise parts

of the decay signal being between the early and the late parts.

4. A measurement equipment for mapping the geology in an subterranean formation, and which comprises:

- at least one transmitter coil for placing above the formation and for building up a magnetic field in said formation by means of the magnetic moment, which the coil transmits when an electric current flows through the coil, and

- at least one receiving coil for placing above the formation and in form of decay signals measuring the decay of builded magnetic field, after the current through the transmitter coil suddenly has been interrupted,

c h a r a c t e r i z e d in,

that the measurement equipment comprises a number of transmitter coils which are adapted, in a chronological order, to transmit a combination of magnetic moments.

5. A measurement equipment according to claim 4, c h a r a c t e r i z e d in that at least two of the transmitter coils have different blanking times.

6. A measurement equipment according to claim 4 or 5, c h a r a c t e r i z e d in that there in at least one of the transmitter coils are inserted more electronic blanking current circuits for simultaneously switching off the winding secpions in the transmitter coil.

7. A measurement equipment according to claim 6, c h a r a c t e r i z e d in that each transmitter coil has a greatest geometric extension in operation position of between 1/4 and 15

metres, preferably between 1/2 and 10 metres and especially between 1 and 6 metres.

8. A Measurement equipment according to each of the claims 4 - 7, c h a r a c t e r i z e d in that each of the transmitter coils can be folded up to an oblong unit.

9. A measurement equipment according to each of the claims 4 - 8, c h a r a c t e r i z e d in that the transmitter and the receiving coils are coupled together in rows and placed upon transport means, such as sledges.

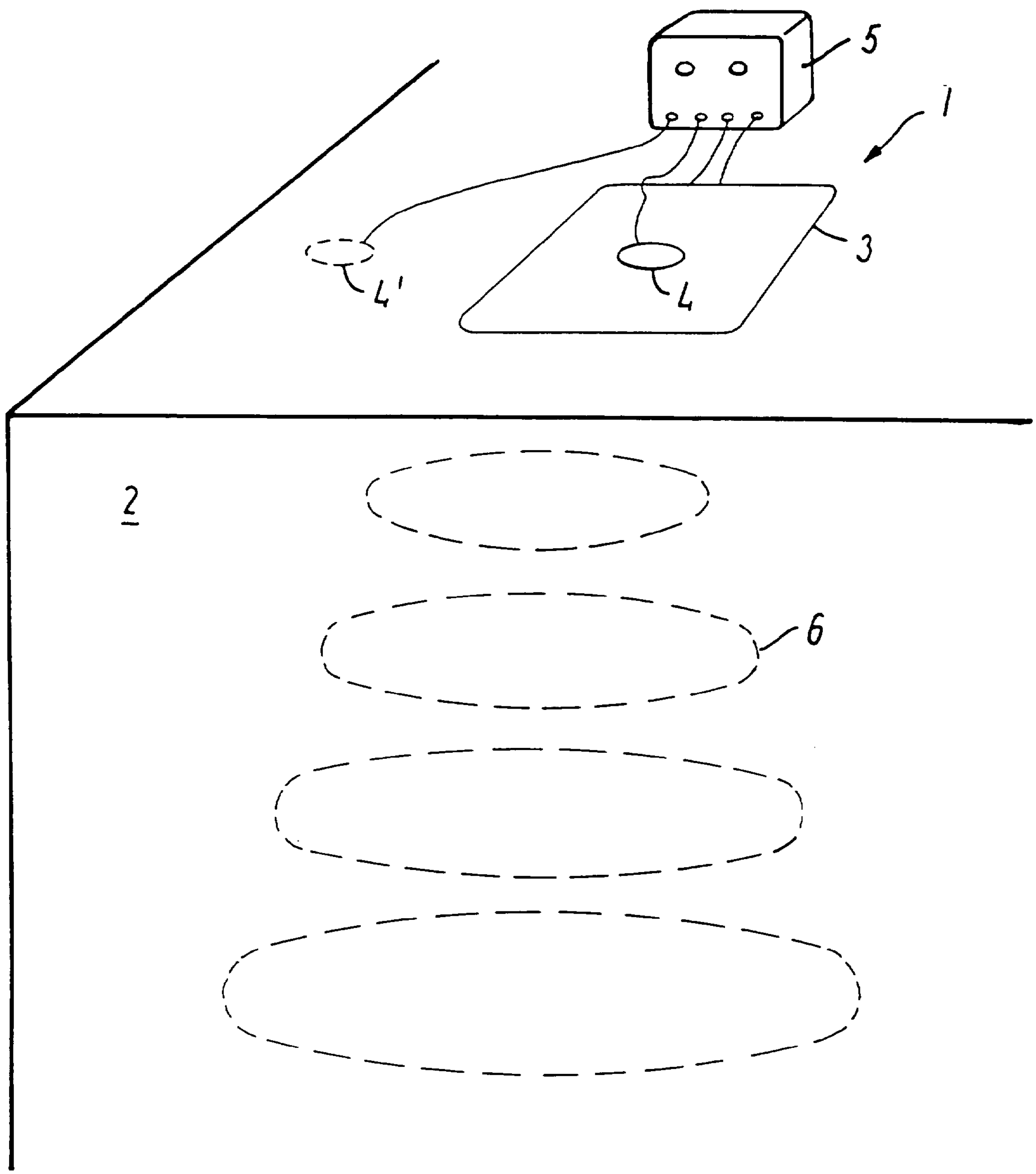

FIG. 1

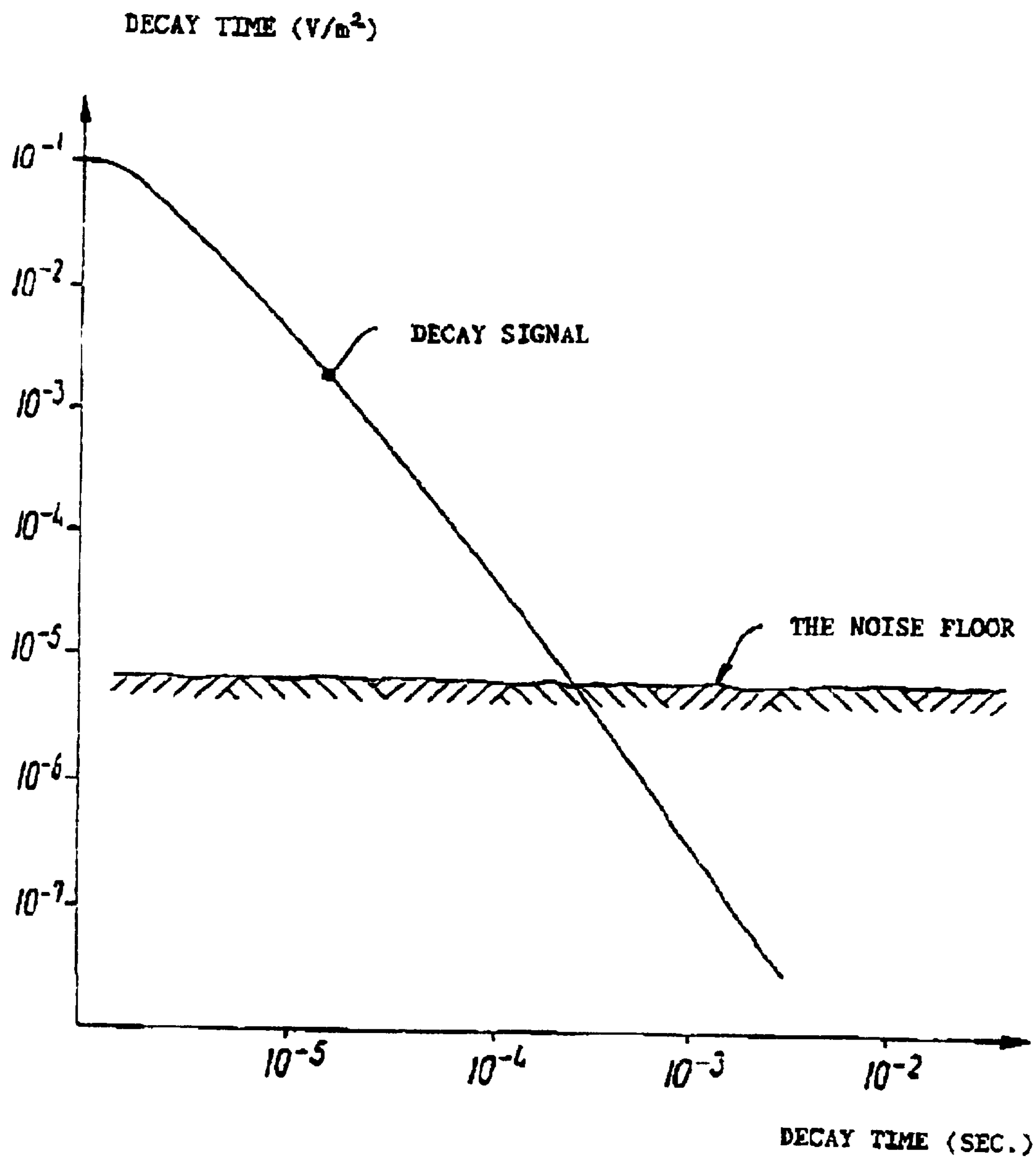
DECAY TIME (V/m²)
10⁻¹
10⁻²
10⁻³
10⁻⁴
10⁻⁵
10⁻⁶
10⁻⁷
DECAY SIGNAL
THE NOISE FLOOR
10⁻⁵
10⁻⁴
10⁻³
10⁻²
DECAY TIME (SEC.)

FIG.2

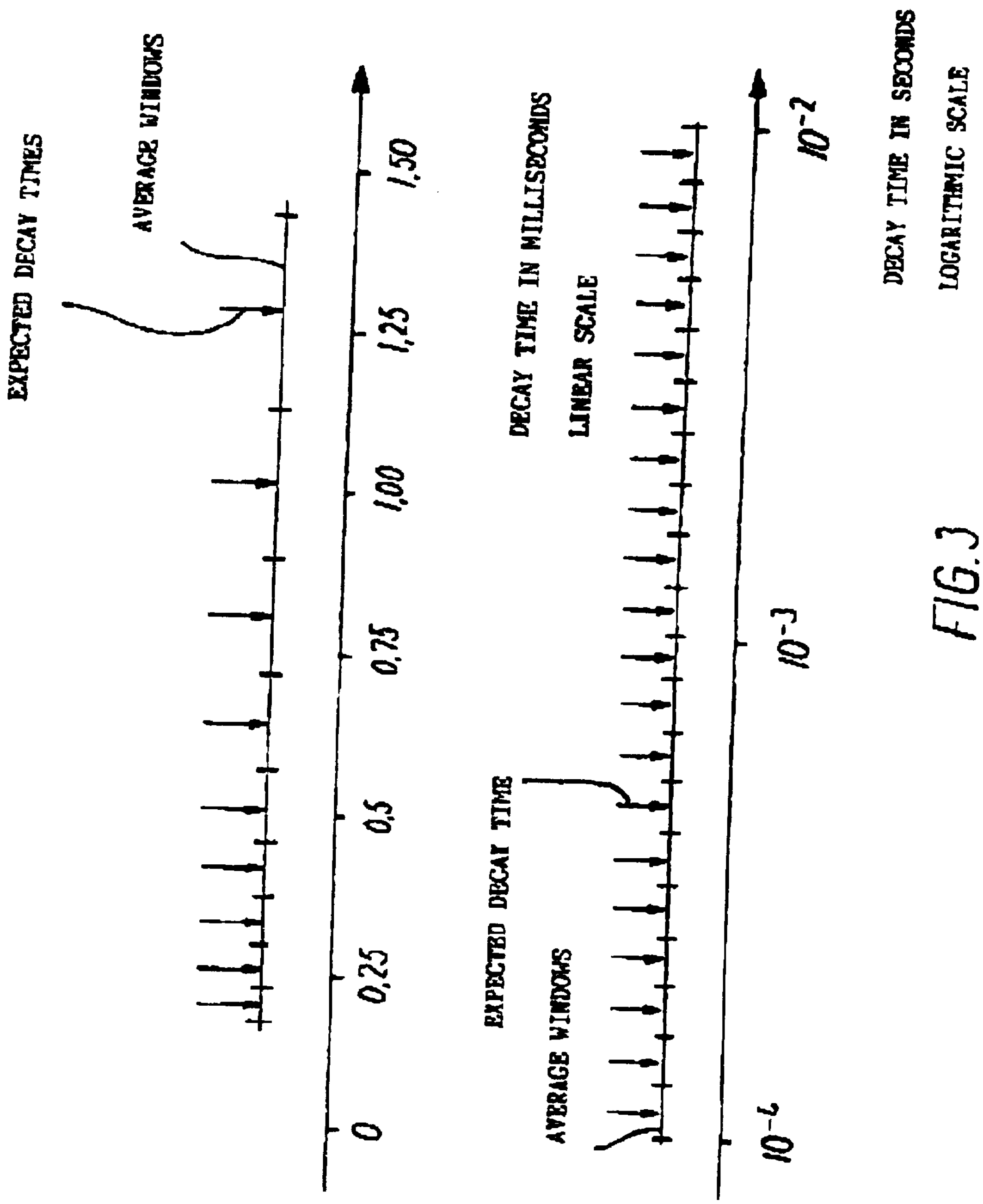
EXPECTED DECAY TIMES
AVERAGE WINDOWS
0
0,25
0,5
0,75
1,00
1,25
1,50
DECAY TIME IN MILLISECONDS
LINEAR SCALE
EXPECTED DECAY TIME
AVERAGE WINDOWS
10^{-4}
10^{-3}
10^{-2}
DECAY TIME IN SECONDS
LOGARITHMIC SCALE

FIG. 3

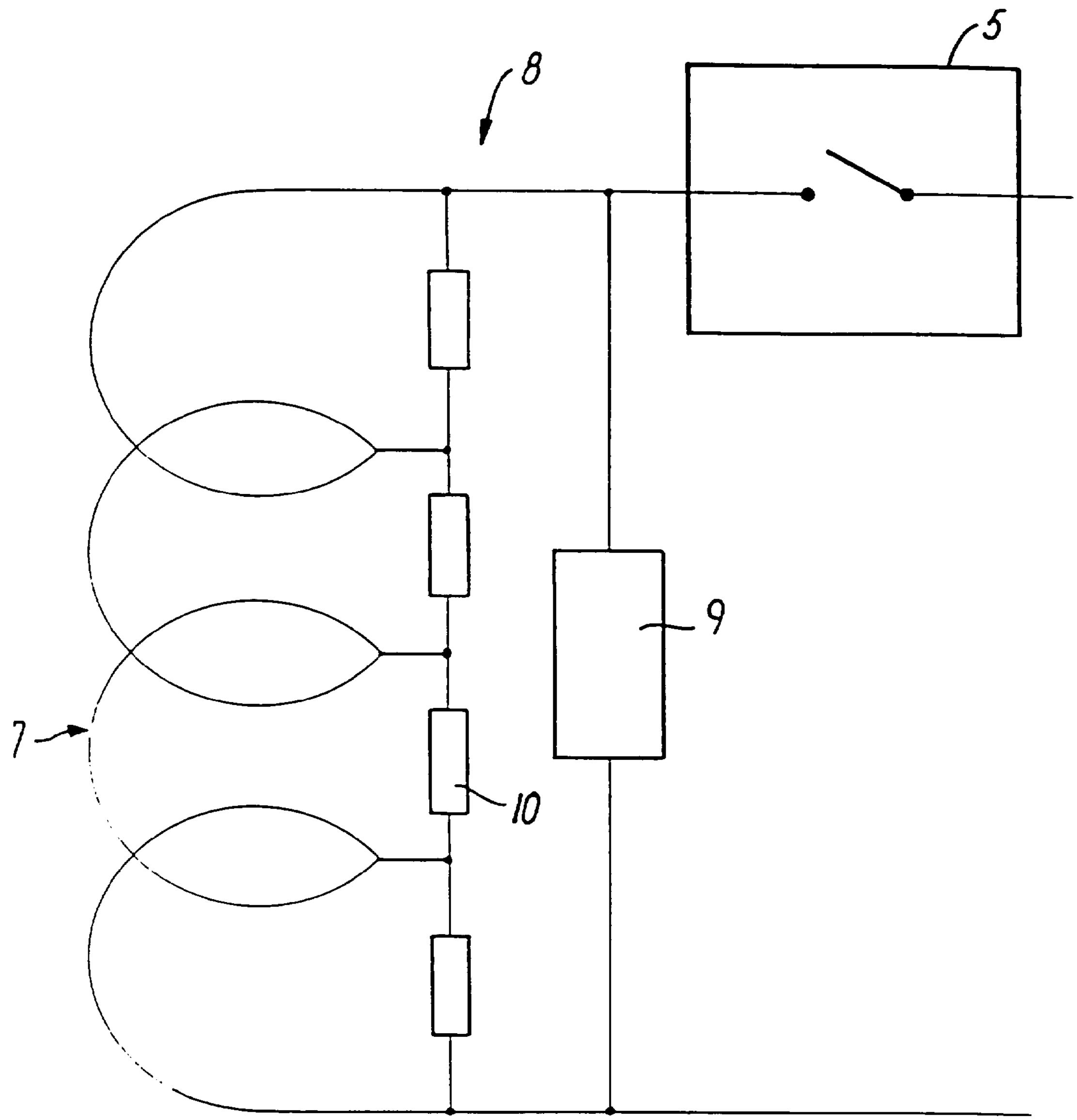

FIG.4

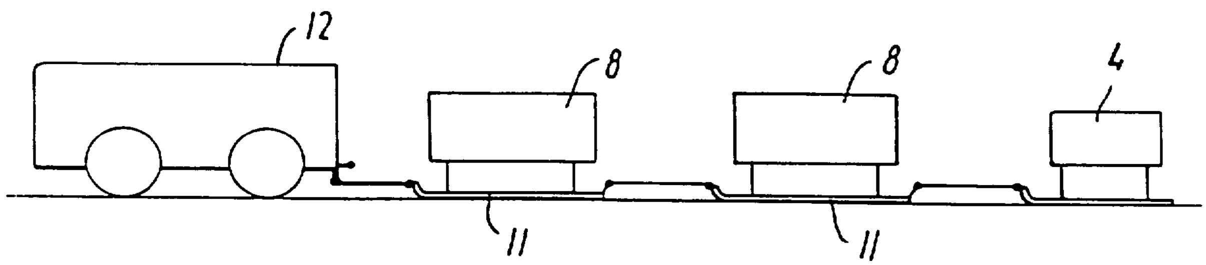

FIG.5a

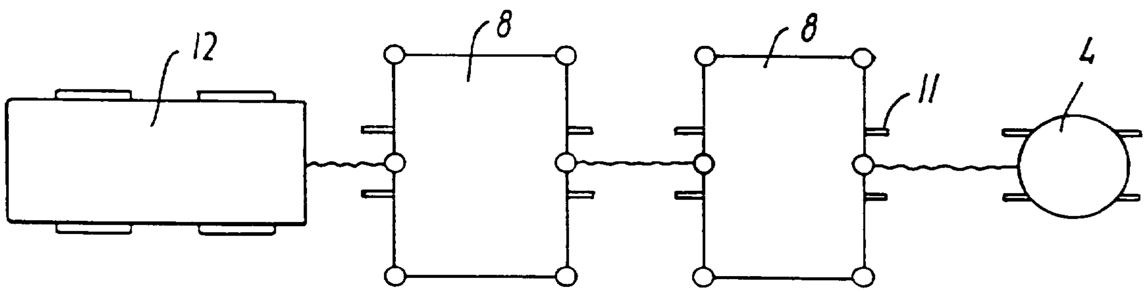

FIG.5b

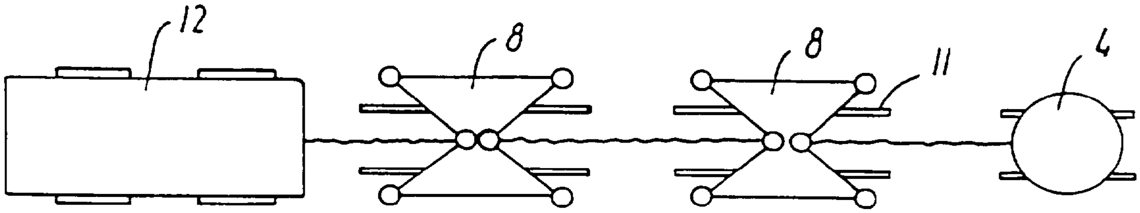

FIG.5c

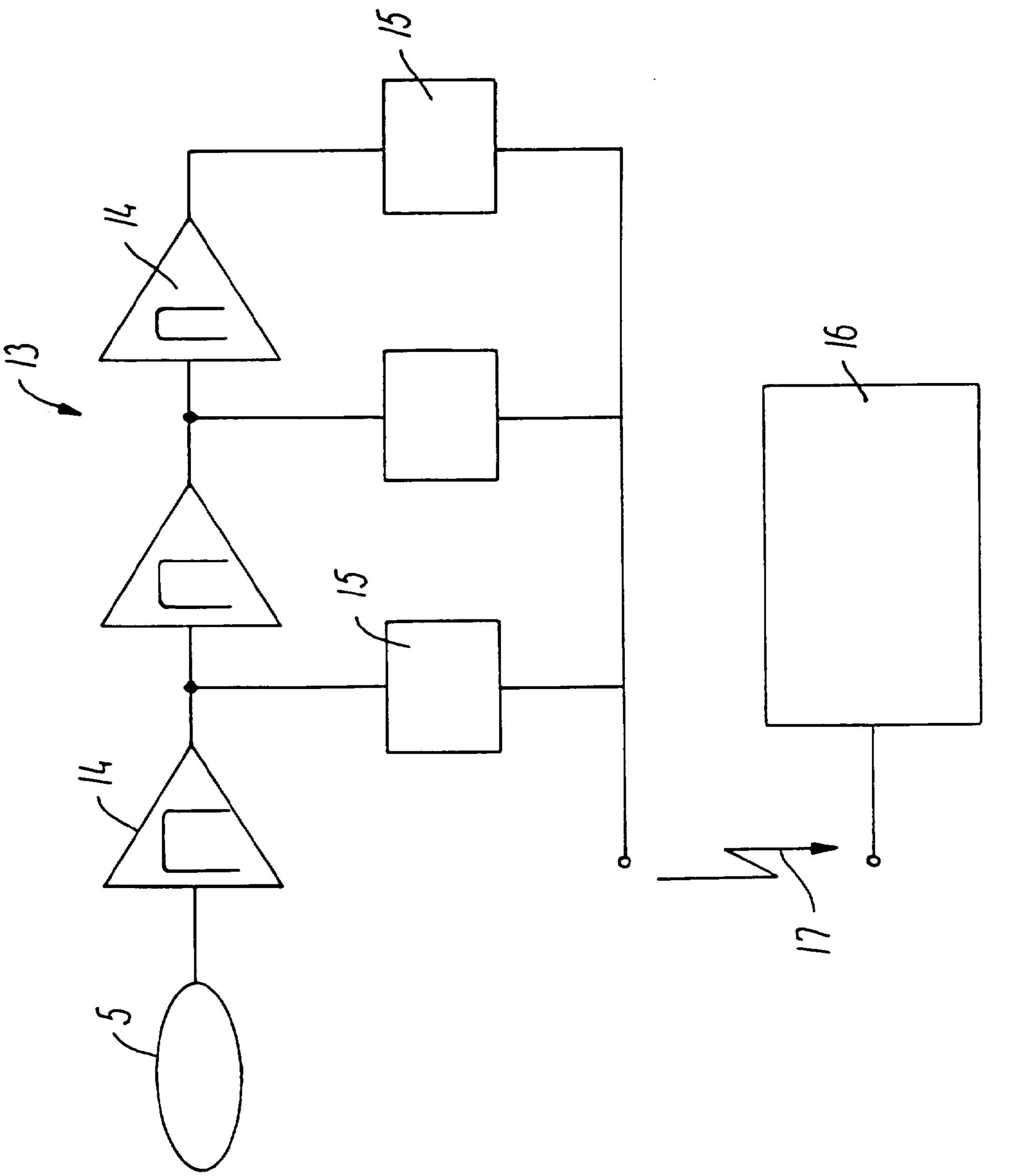

FIG.6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/DK 96/00173

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: G01V 3/10 // G01N 3/15
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: G01V

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0087271 A2 (GEONICS LIMITED), 31 August 1983 (31.08.83), page 6, line 1 - line 21, figures 1,3, abstract	1
A		5
	--	
X	WO 9219989 A1 (ELLIOTT, PETER, JOHN), 12 November 1992 (12.11.92), page 6, line 21 - page 7, line 16; page 8, line 27 - page 9, line 13, abstract	1
A		5
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☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
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"E" erlier document but published on or after the international filing date
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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
26 August 1996	27 -08- 1996

Name and mailing address of the ISA/	Authorized officer
Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Max Olofsson Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT

Information on patent family members

31/07/96

International application No.
PCT/DK 96/00173

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
EP-A2-	0087271	31/08/83	SE-T3-	0087271	
			AU-B-	556402	30/10/86
			AU-A-	1126383	25/08/83
			CA-A-	1133058	05/10/82
			JP-A-	58151575	08/09/83
			US-A-	4544892	01/10/85
WO-A1-	9219989	12/11/92	AU-B-	647270	17/03/94
			CA-A-	2109118	07/11/92
			DE-T-	4291398	28/04/94